Raspberry Pi Architecture
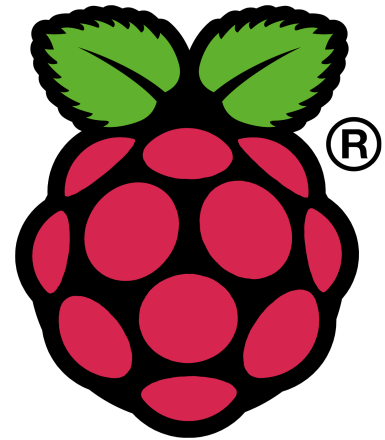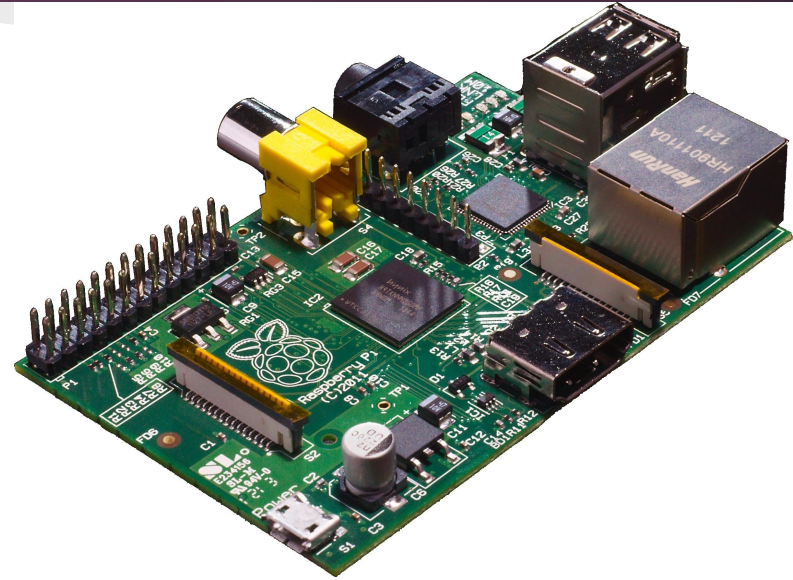
Jon Holton and Tim Fratangelo

Agenda

- Background Info
- Full Architecture Overview
- CPU Overview
- CPU Pipeline Stages
- Branch Prediction and Folding
- GPU Overview
- Applications
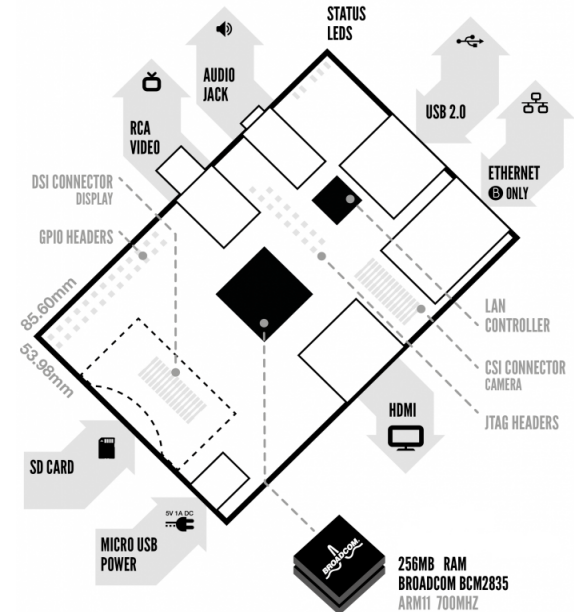
www.sparkfun.com

Background Info

- Created by Eben Upton, Rob Mullins, Jack Lang and Alan Mycroft at University of Cambridge

- They, in conjunction with Pete Lomas and David Braben, formed the Raspberry Pi Foundation

- The Model B was mass produced by Premier Farnell and RS Electronics in 2011

- Was created to provide inexpensive programming machines to today's youth

Raspberry Pi Foundation

Full Architecture Overview

- Two Models A & B, priced at $25 and $35 respectively
- Model A/B:
  - Broadcom BCM2835 (CPU & GPU)
  - 256/512MB SDRAM
  - 1/2 USB 2.0 Ports
  - None/Ethernet Port
  - HDMI
  - Audio
  - SD Card Slot
  - Micro USB for power

Raspberry Pi Model A B

STATUS LEDS

AUDIO JACK

USB 2.0

RCA VIDEO

DSI CONNECTOR DISPLAY

ETHERNET B ONLY

GPIO HEADERS

LAN CONTROLLER

CSI CONNECTOR CAMERA

HDMI

JTAG HEADERS

85.60mm

53.98mm

SD CARD

5V 1A DC

MICRO USB POWER

256MB RAM
BROADCOM BCM2835
ARM11 700MHZ

elinux.org

BCM2835: CPU Overview

- ARM11J6JZF-S (ARM11 Family)
- ARMv6 Architecture
- Single Core
- 32-Bit RISC
- 700 MHz Clock Rate
- 8 Pipeline Stages
- Branch Prediction

ARM 1176 Processor
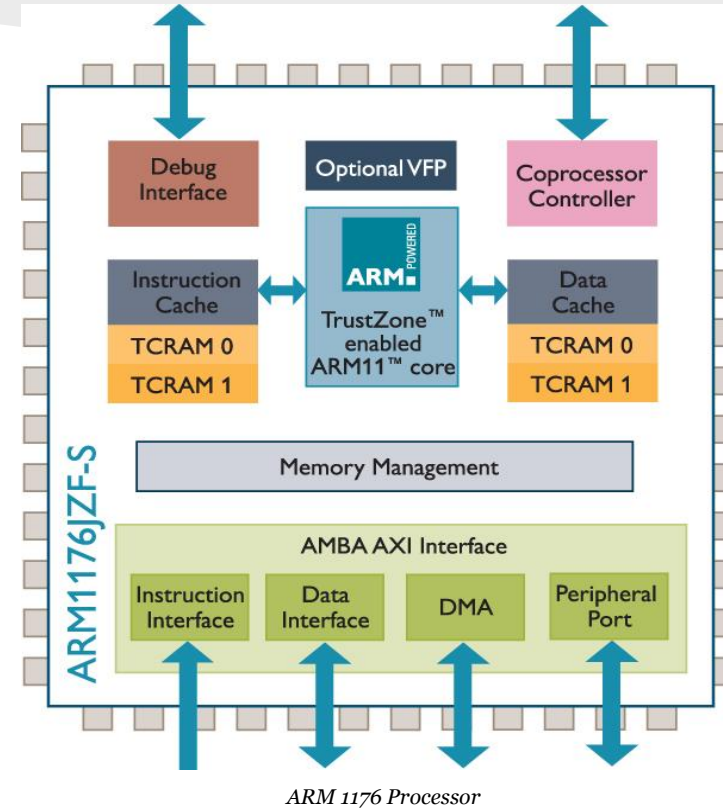
BCM2835: CPU Overview

- Core
- Load Store Unit
- Prefetch Unit
- Memory System
- Level One Mem. System
- Interrupt Handling
- System Control

- AMBA Interface
- Coprocessor Interface
- Debug
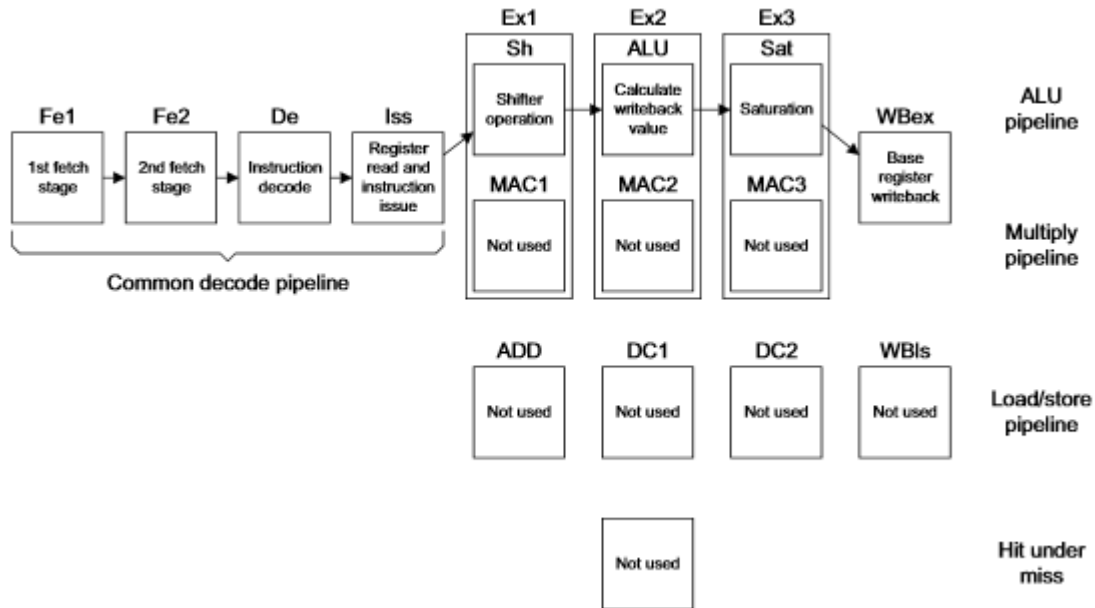- Instruction cycle summary and interlocks
- Vector Floating-Point

ARM1176JZF-S Technical Reference Manual
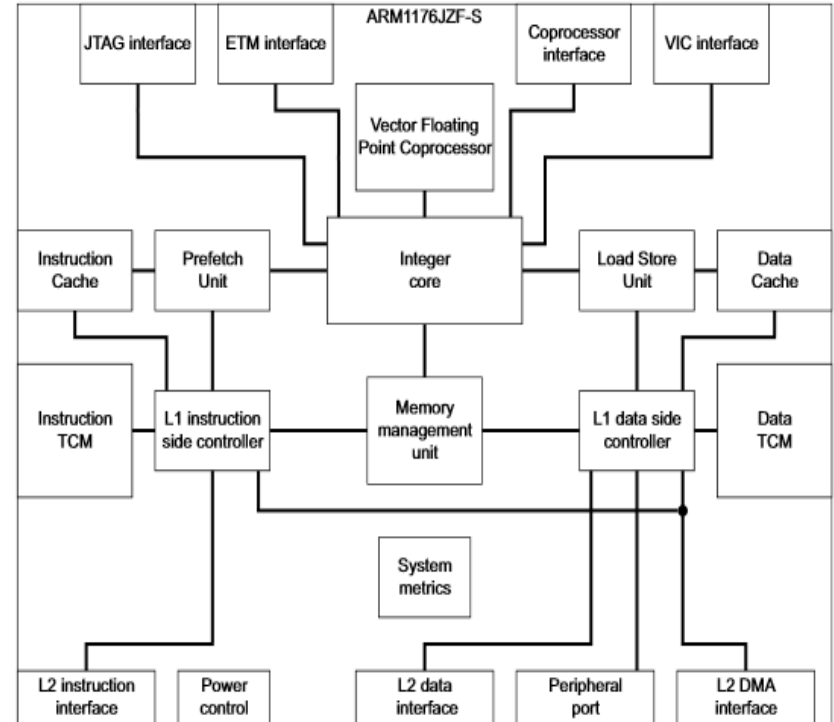
CPU Pipeline Stages

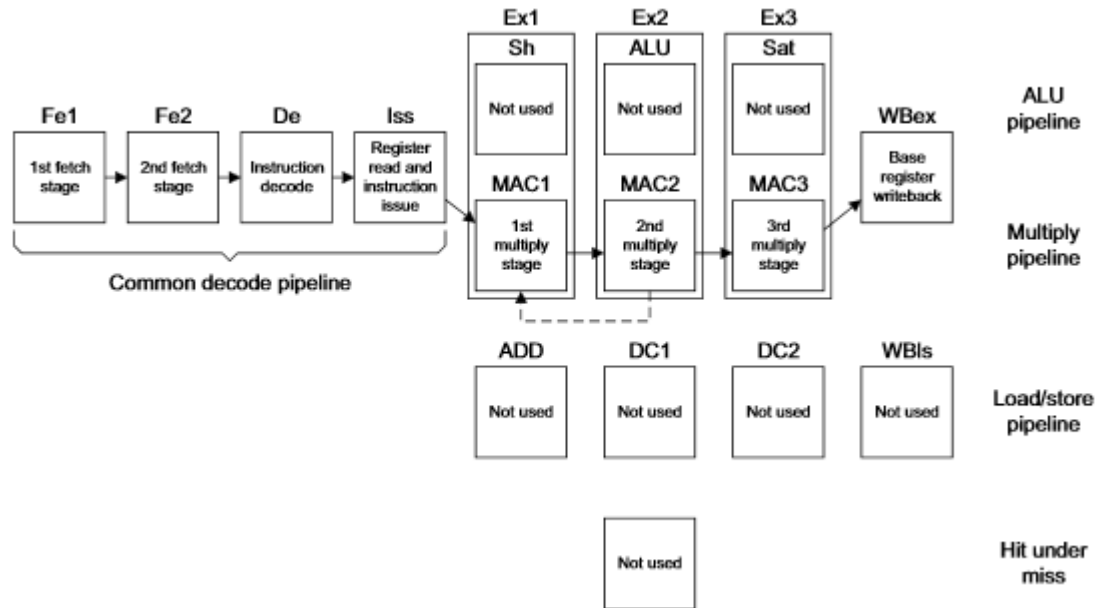## Pipeline stages used by ARM1176JZF-S
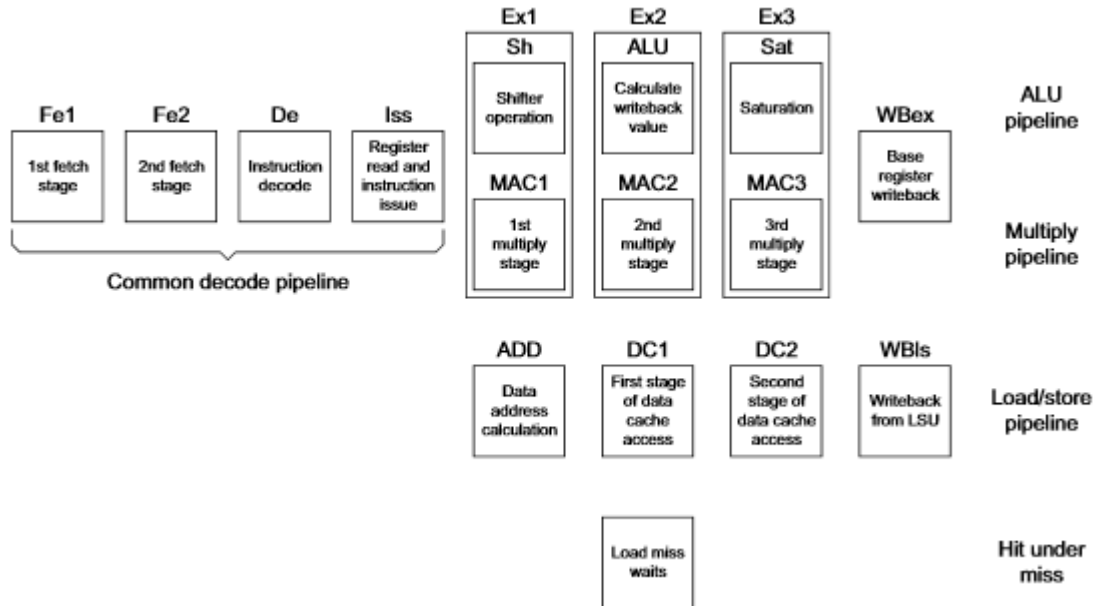
CPU Pipeline Flow

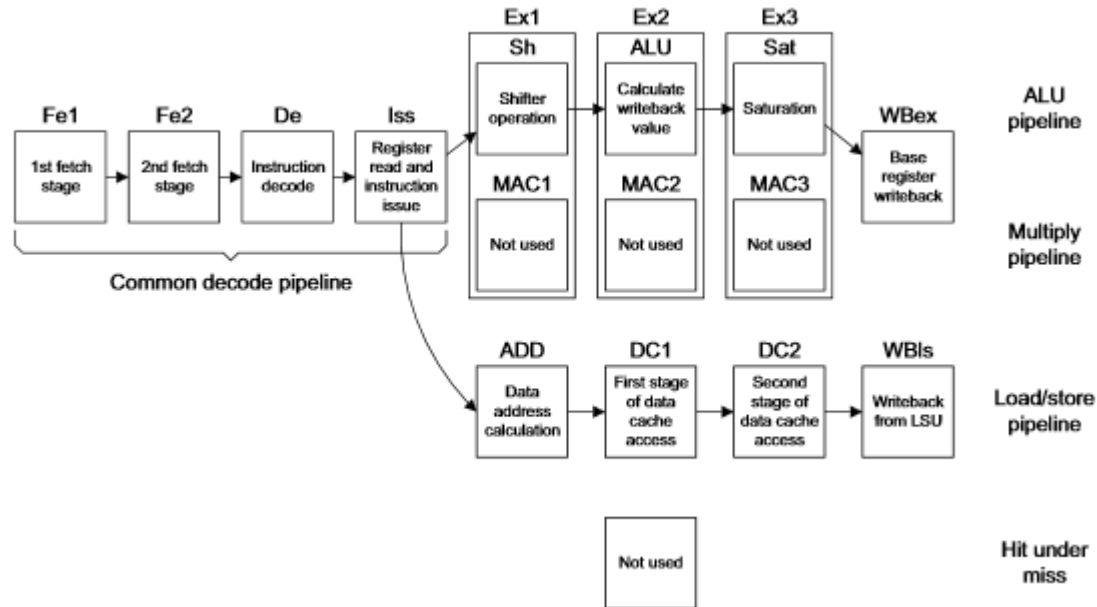## Execution flow for ALU operations

CPU Pipeline Flow

## Execution flow for Multiply Operations

CPU Pipeline Flow

Execution flow for Load/Store Operations

CPU Cache Organization

- Harvard Implementation (Simultaneous access for program memory and data memory)

- Write policy can be either write-back or write-through

- Replacement policy is either pseudo-random or round robin (controlled by RR bit)

ARM1176JZF-S Technical Reference Manual
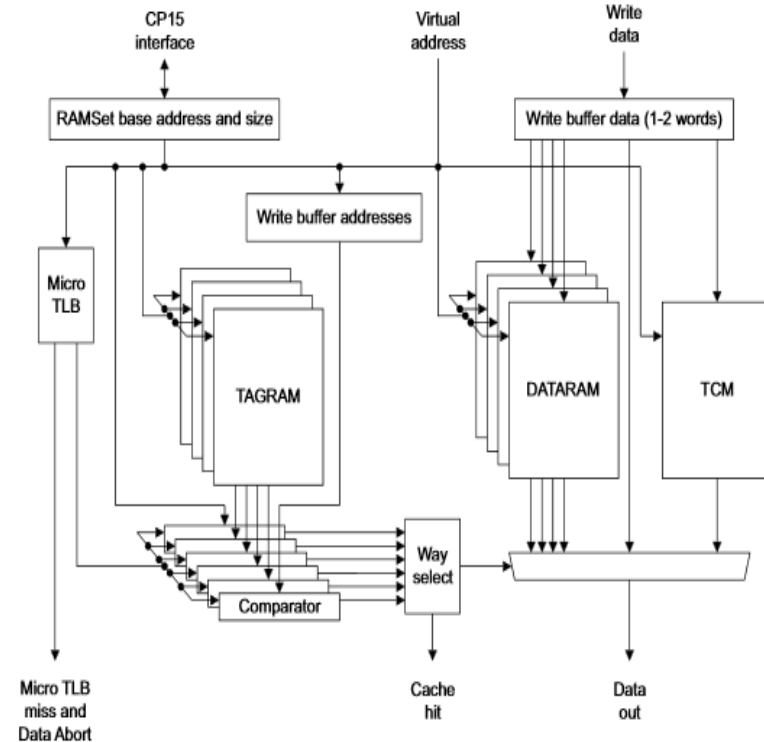
BCM2835: Branch Prediction

- The Fetch stage can hold up to four instructions, allowing for prediction to occur on held instructions

- All predictions are resolved by the third execution stage

- Uses dynamic Prediction when there is a history associated with a branch

- Uses static prediction without history
  - backward branches being predicted as taken
  - forward branches as not taken.

- Two addresses are stored in the case of a failed prediction:
  - Recovery address if branch taken was predicted
  - Target address if branch not taken was predicted

ARM1176JZF-S Technical Reference Manual

BCM2835: Branch Folding

Branch instructions are removed from the pipeline if the following conditions are met:

- The instruction is not a branch with a link
  (address is stored in a linked register)
- The instruction does not point to a code sequence that contains a branch in the first two instructions
- The instruction is not break-pointed
- The instruction is not aborted

This method can produce a CPI for branch instructions that is much lower than 1

BCM2835: GPU Overview

- Broadcom Videocore IV
- Uses OpenGL ES2.0
- Performance: 24 GFLOPS
- RPi can play 1080p Blu-Ray quality videos
- Graphical capabilities are similar to the those of the original XBOX
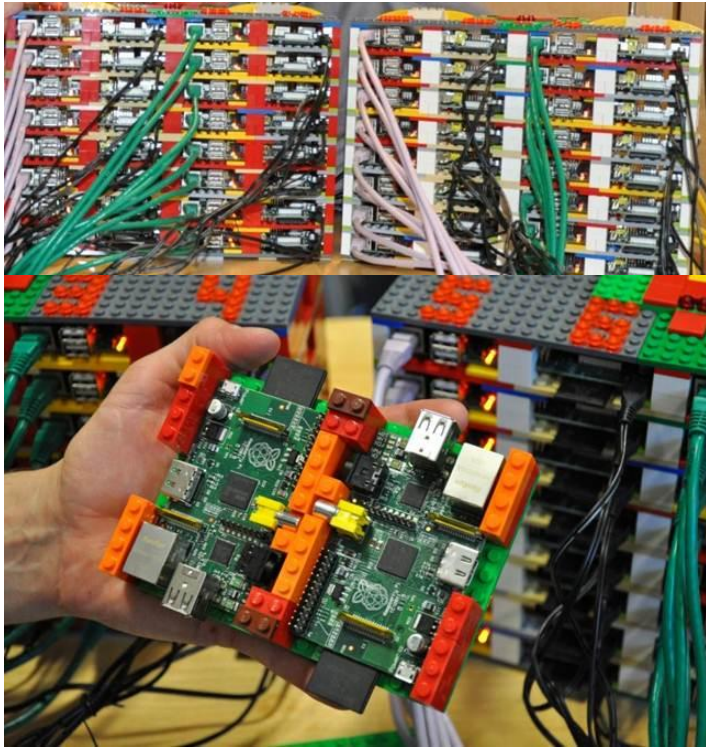
Videocore IV GPU

Applications and Uses

- Robotics
- Game emulation
- Media Servers
- Education (Python is the primary language used)
- Powerful enough to be used as a personal computer
- Thousands of other projects (Often used in Senior Design)

SNESDev-RPi

64 Raspberry Pi Cluster

- 64 Raspberry Pi's

- Total power usage ~192 watts

- Each Pi's GPU provides ~24 gigaflops in graphical processing power

(S. Cox, 2012)
(Ars Technica, 2012)

Questions?

References

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ARM1176JZF-S Technical Reference Manual
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Sparkfun.com

https://www.sparkfun.com/tutorials/372